

CURRENT STATUS AND CONSERVATION OF FALCONIFORMES IN TROPICAL ASIA

JEAN-MARC THIOLLAY

Laboratoire d'Ecologie, E.N.S., 46, rue d'Ulm 75230 Paris Cedex 05, France

ABSTRACT.—I reviewed the distribution, abundance, habitat selection, and population trends of 69 diurnal raptors found in 13 subregions from India to Indochina, Sumatra, and Java. At least four species are Endangered or Vulnerable and 19 are at lower risk or have insufficient data to determine their status. Among 49 breeding species, 33 have a world range mostly within South Asia, half with high conservation value scores. Others have small (six species) or substantial (10 species) populations but a much wider distribution. Of all 69 taxa, eight are mature forest-interior species, six are associated with gaps or disturbance, 14 are woodland, edge, or upper canopy dwellers, 14 are associated with grasslands or cultivation, and seven are river or wetland species. Most wintering migrants (20) are nonforest species. There is evidence of largescale population declines on the continent of Asia, as well as insular syndrome involving increased density and wider habitat breadth on islands. The most important threats to diurnal raptors are (1) habitat loss, especially of lowland rainforest to cultivation, (2) habitat degradation, mainly from logging, and (3) forest fragmentation. Few species are successfully adapting to new man-made habitats and none are from the forest-interior guild. Main conservation priorities include surveys and ecological studies, extension and enforcement of protected areas, and sustainable logging practices.

KEY WORDS: *raptor populations; South Asia; distribution; conservation.*

Estado actual y conservación de falconiformes en el Asia tropical

RESUMEN.—Resumí la distribución, abundancia, selección de habitat, y tendencias poblacionales de 69 aves rapaces diurnas de 13 subregiones desde India hasta Indochina, Sumatra, y Java. Por lo menos 4 especies están amenazadas o son vulnerables, 19 están en menos riesgo o no existe información suficiente para determinar su estado. Entre las 49 especies, 33 tienen un área de distribución dentro del Sur de Asia, la mitad de estas tienen un valor de conservación alto. Otras tienen poblaciones reducidas (6 especies) o substanciales (10 especies) con distribuciones mas amplias. De todos los 69 taxones, 8 son especies del interior de bosques maduros, 6 estan asociados a zonas abiertas o disturbadas, 14 son especies de bosque, borde o dosel, 14 están asociados a pastizales o cultivos, y 7 son especies de ríos o humedales. Casi todas las migratorias (20) no son especies de bosque. Existen evidencias sobre la disminución poblacional de las especies a gran escala en el continente Asiático, como tambien sobre el síndrome insular que incluye el aumento de densidades y espacios entre habitats en islas. Las amenazas mas importantes para las aves rapaces diurnas son: (1) Pérdida de habitat, especialmente de los bosques de lluvia de tierras bajas convertidas a cultivos, (2) degradación del habitat a partir de actividades forestales, y (3) fragmentación del bosque. Pocas especies se están adaptando exitosamente a los nuevos habitats creados por el hombre. Las prioridades de conservación, incluyen investigaciones y estudios ecológicos, apoyo y extensión de áreas protegidas y prácticas forestales sostenibles.

[Traducción de César Márquez]

Several Asian countries have the densest and fastest growing human populations in the world, as well as the fastest growing economies and standards of living. As a result, there is dramatic pressure on natural habitats, resources, and biodiversity of this area.

Raptors are good indicators of environmental changes because they are top predators, they include species with a variety of specific habitat re-

quirements, prey selection and degrees of tolerance to disturbance, and their species numbers, at least in some areas, are correlated with the total bird species richness (Thiollay 1997). My aim here is to review the composition, distribution, population levels, and conservation priorities of diurnal raptors in Southeast Asia in the early 1990s. Most information about the geographical distribution of raptor species is scattered in the literature and

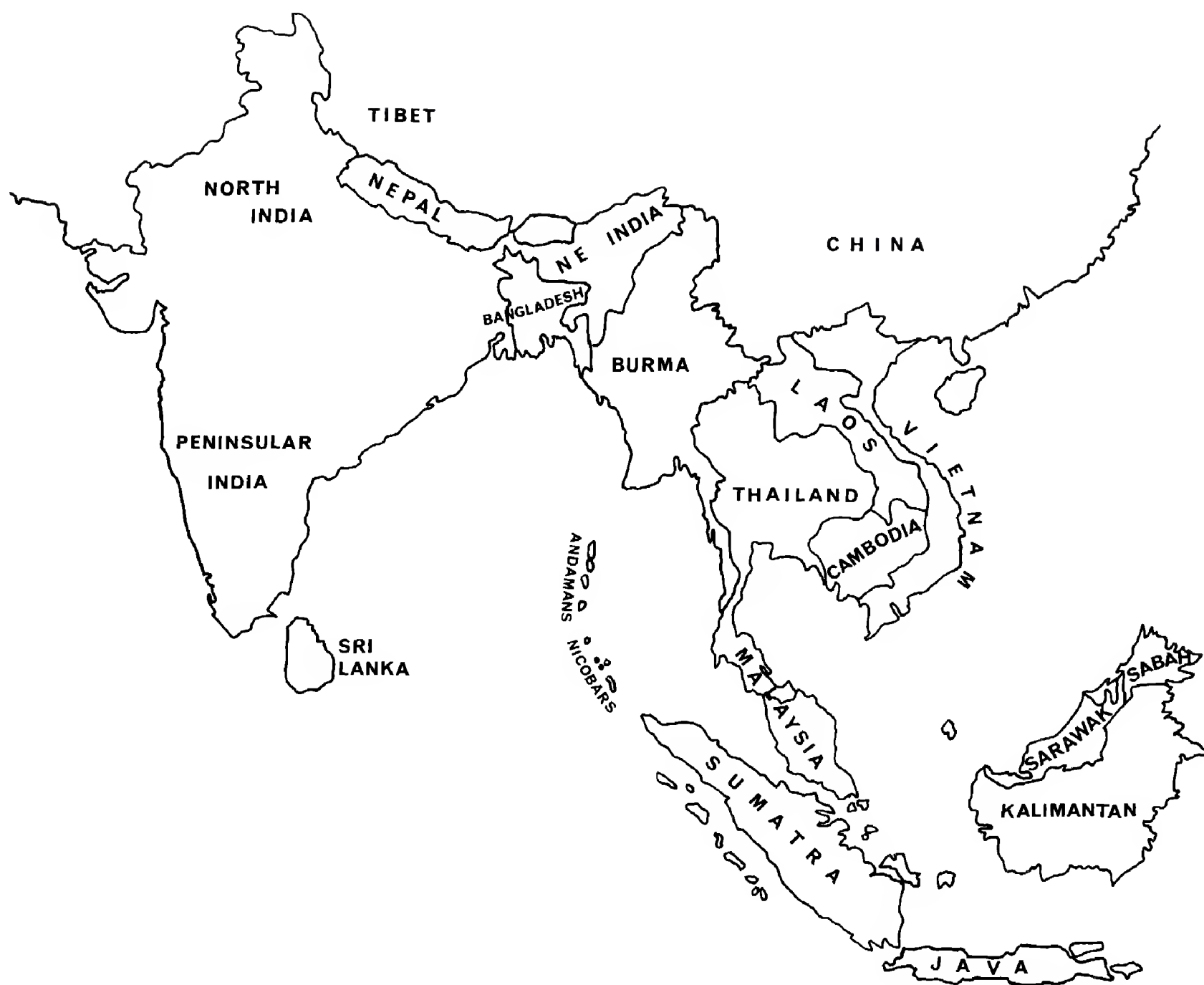


Figure 1. Study area and regional divisions.

much less is known about their habitat selection and their actual abundances. These last critical components of their status are rapidly changing and may be different today than they were reported in regional syntheses based on information that is decades old. To update and complement published data, I shall rely primarily on the results of numerous personal raptor surveys and field studies carried out in 27 states or provinces in eight countries during the last 20 yr.

STUDY AREA

The area under consideration extends from India to Indochina, south of the Himalayas and China, and down to the Greater Sundas, west of the Wallace Line (Fig. 1). This is a faunistically homogeneous, 7 million-km² region, that now has a human population of >1.4 billion people. It is divided into three broad biogeographic zones: Indian (India to Burma), Indochinese (Thailand

to Vietnam), and Sundan (Malaysia to Java). In terms of its raptors, the area can be divided more precisely into 13 subregions (Table 1).

The main vegetation type is a rich, closed-canopy, moist forest with trees approximately 50 m in height (Whitmore 1985). At best, only 42% of the original forest remains (global estimate from Collins et al. [1991], assuming a constant deforestation rate since the 1980s). This estimate includes evergreen to semi-deciduous, lowland and montane forests that have often already been logged or degraded, where annual rainfall is 2–4 m or more and no month receives under 60 mm of precipitation. At higher latitudes, marked dry seasons (≤ 3 months with <60 mm of rainfall) result in drier, more deciduous monsoon forests grading into lower woodlands or even subdesert scrubland in north western India. Lowland swamp forests are locally extensive in Borneo and Sumatra. Mangroves (*Avicennia*, *Rhizophora*) are widespread along low coastlines and estuaries and cover over 4000 km² in the Sundarbans of Bangladesh alone. Former coastal forests have been replaced by coconut

Table 1. Total size of study areas, remaining forested areas (1980–88), and existing protected areas in 1000s of km² (from Collins et al. 1991).

SUBREGIONS	LAND AREA	RAIN FOREST	MONSOON FOREST ¹	MANGROVE AND SWAMP FOREST	PROTECTED AREAS ²
Northern India ^a	1805.9	0.9	98.1	1.2	106.0
Peninsular India	944.6	20.0	18.4	0.1	16.6
Northeastern India ^b	640.4	46.7	38.8	4.5	9.3
Sri Lanka	64.7	1.4	10.8		7.2
Andamans-Nicobars	6.3	2.6	3.6	0.6	0.6
Burma (Myanmar)	657.7	220.3	88.4	3.0	7.0
Thailand + Cambodia	688.3	127.4	79.2	13.4	66.9
Laos + Vietnam	556.1	134.3	45.3	1.6	8.2
Peninsular Malaysia ^c	330.3	64.5		5.2	6.2
Northern Borneo	203.9	113.5		21.7	8.1
Kalimantan	532.1	323.6		73.7	29.7
Sumatra ^d	472.6	155.3		75.3	45.0
Java + Bali	138.6	12.8		9.2	3.7
Total	7041	1223	382	209	314

¹ Includes both lowland and montane forest, and from intact to highly degraded stands.
² Includes also nonforest areas and low protection status areas such as protection forests or hunting reserves.
^a North of 20°N, excluding Himalayan and Tibetan ranges.
^b Includes Bangladesh.
^c Includes Peninsular Thailand, Tenasserim and Singapore.
^d Includes outlying islands.

plantations. Upper montane areas above tree line are insignificant in size.

Wetlands are mostly associated with rivers and to a lesser extent with marshes, peat swamps, coastal lagoons, many artificial lakes, and vast areas of temporarily inundated ricefields. Permanent agriculture is often intensive over huge, densely-inhabited areas. Nevertheless, a substantial density of trees, patches of grassland for cattle grazing, and fallow areas with low second growth are retained. In more remote and forested areas on slopes, shifting cultivation has resulted in various successional stages of secondary growth. Tree plantations are often extensive. They range from the diversified, forest-like agroforests of Indonesia to the vast and uniform industrial plantations of fast growing exotic trees grown for fuel or pulpwood (*Eucalyptus*, *Gmelina*, and *Acacia*), lumber (*Tectona*, *Pinus*, and *Dipterocarpaceae*), fruit (*Mango*), and especially rubber (*Hevea*) and oil (*Elaeis*). Together with open cultivated woodlands and home gardens, they currently cover much larger areas than natural forests. Urban, industrial, and recreational areas are increasing everywhere with the increasing human population and economic development.

METHODS

Only resident and regular wintering migrant diurnal raptors were considered, while vagrants and transient migrants were ignored. I surveyed raptor populations over extensive areas from 1975–95, mostly in Nepal, northern and southern India, Andamans, Sri Lanka, Malaysia, Borneo, Sumatra, Java, Laos, and Vietnam. In each region,

two sets of methods were used to assess the relative abundance and habitat selection of raptors. First, extensive transect counts were made along roads, tracks, and forest trails, either by car with numerous stops or on foot. The second method was an adaptation of the point count method (Thiollay 1989, 1995) where 1-km² sample quadrats, predominantly covered by a single habitat type, were censused for 4 hr from vantage lookouts during morning periods (0900–1200 H) when most raptors were active. The results were expressed in mean number of individuals, respectively, per km of transect or per 1-km² sample plot. Differences between these abundance indices (within, but not between species, because of unequal detectabilities) were tested among habitats and study areas using Kruskal-Wallis one-way ANOVA, followed by a non-parametric multiple pair-wise comparison procedure based on two-tailed Mann-Whitney *U*-tests (Sokal and Rohlf 1981).

Habitat types, where each individual raptor was recorded in cumulative random samples, were used to assess specific habitat selection compared to habitat availability using the method of Neu et al. (1974). Thus, species were classified into broad categories of habitat preference, illustrating their distributional trend along the habitat gradient from primary forest to deforested habitats and their ability to withstand increasing deforestation. Random records were also used to measure specific habitat niche breadth, $\beta = \sum(p_i^2)^{-1}$, where p_i was the proportion of birds sighted in the i^{th} habitat category. Two-tailed sign tests were used for interspecific comparisons of habitat niches.

Table 2. Component scores of the conservation index attributed to tropical Asian raptors. The total index was the sum of the species rank value in each of three parameters.

RANK	CONSERVATION PARAMETERS		
	RANGE AREA	MAIN HABITAT	POPULATION TREND
0	>75% of S. Asia	Open and cultivated habitats	Stable or increasing
1	50–75% of S. Asia	Forest edges or woodlands	Probable but undocumented decline
2	25–49% of S. Asia	Disturbed or secondary forests	Moderate or locally documented decline
3	<25% of S. Asia	Primary forest interior	Significant and widespread decrease

The following habitat categories were defined: WET, all wetlands from marshes, lakes and rivers to swamp forests and mangroves; CULT, grasslands and cultivated areas; TREE, open woodlands, orchards, isolated woodlots, and edges; FOR 1, highly degraded forest with dense second growth and open canopy, as well as tree plantations; FOR 2, secondary forest heavily logged or disturbed and agroforests; FOR 3, high, submature but logged forest with almost continuous canopy; and FOR 4, large tracts of dense, mostly evergreen, undisturbed, primary forest.

Most accounts are based on personal observations either unpublished or in Thiollay (1978, 1983, 1993, 1995, 1996, 1997) and Thiollay and Meyburg (1988), and supplemented by information provided by numerous ornithologists. The following references were used to summarize data available for each country not personally surveyed and to estimate population trends by comparison with past status: Baker 1928, Delacour and Jabouille 1931, Whistler 1941, Deignan 1963, Smythies 1953, 1981, Wildash 1968, Henry 1971, King et al. 1975, Medway and Wells 1976, Ali and Ripley 1978, Morris 1986, van Marle and Voous 1988, Lekagul and Round 1991, MacKinnon and Philipps 1993, del Hoyo et al. 1994.

A numerical conservation index was assigned to each species whose breeding population was mostly within the study region according to Usher (1986). It was the sum of three 0–3 scores, such that the species with the most limited geographic range and habitat preference, the highest forest use, and the most declining populations (e.g., the most Vulnerable or Threatened species) got the highest ranking (Table 2). All values were conservative estimates to avoid an overemphasis of the threat level.

RESULTS

Raptor Community Composition and Distribution. In South Asia, 20 species of Falconiformes are nonbreeding migrants and are found only in winter. They include 12 widespread species (5 harriers (*Circus* spp., Chinese Goshawk [*Accipiter soloensis*], Japanese Sparrowhawk [*A. gularis*], Grey-faced Buzzard [*Butastur indicus*], Common Buzzard [*Buteo buteo*], Steppe Eagle [*Aquila nipalensis*], Booted Eagle [*Hieraaetus pennatus*], and Eurasian Hobby [*Falco subbuteo*]). Eight species (Eurasian Black Vulture [*Aegypius monachus*], Eurasian Sparrowhawk [*Accipiter nisus*], Long-legged Buzzard [*Buteo rufinus*],

Greater Spotted Eagle [*Aquila clanga*], Eurasian Imperial Eagle [*A. heliaca*], Lesser Kestrel [*Falco naumanni*], Merlin [*F. columbarius*], and Saker Falcon [*F. cherrug*]) are rare or local in their occurrence.

Among the 49 breeding species, 15 are spread over the three geographical zones, eight are in two zones, 20 are in only one zone, and six are restricted to Andamans or Java (Table 3). The number of resident species steadily decreases from large continental areas (north and northeast India, 35 taxa), the large southern peninsulas (south India to Indochina, 23–28 taxa), narrow peninsulas and the largest islands (Malaysia and Borneo, 19–20 taxa), to more outlying islands (Sri Lanka to Java, 17–18 taxa) and oceanic archipelagoes (4–6 taxa). The reduction in species richness is related to both land area, degree of isolation, and historical factors.

Habitat Selection and Implications. Eight species associated with interior primary moist forests, except the island endemics Andaman Serpent-eagle (*Spilornis elgini*) and Nicobar Serpent-eagle (*S. klossi*), are intolerant of logging or forest fragmentation. These species may have no viable populations outside the current extent of undisturbed forest. Crested Goshawk (*Accipiter trivirgatus*) and Wallace's Hawk-eagle (*Spizaetus nanus*) are almost exclusively found in lowland forest while Jerdon's Baza (*Aviceda jerdoni*) and Javan Hawk-eagle (*Spizaetus bartelsi*) are found at elevations as high as submontane forest. Blyth's Hawk-eagle (*Spizaetus alboniger*) and Mountain Hawk-eagle (*S. nipalensis*) are restricted to hill and montane forests and they withdraw in winter from upper altitudes to lowland India and Malaysia.

Six forest species actually use forest gaps, upper canopy, and edges for hunting and are more tolerant to disturbance, fragmentation, and logging. They may actually benefit from partial opening of

Table 3. Distribution of 49 raptor breeding species within South Asia.

NUMBER OF SPECIES	DISTRIBUTED IN					EXAMPLES
	S TO NE INDIA	ANDAMANS AND NICOBARS	THAILAND TO VIETNAM	MALAYSIA BORNEO SUMATRA	JAVA	
4	+	+	+	+	+	<i>Spilornis cheela</i> , <i>Accipiter virgatus</i>
7	+		+	+	+	<i>Pernis ptilorhynchus</i> , <i>Accipiter trivirgatus</i>
1	+	+				<i>Aviceda leuphotes</i>
4	+		+	+		<i>Aviceda jerdoni</i> , <i>Ichthyophaga humilis</i>
1	+		+		+	<i>Falco severus</i>
1	+			+	+	<i>Falco peregrinus</i>
6	+		+			<i>Accipiter badius</i> , <i>Milvus migrans</i>
11	+					<i>Butastur teesa</i> , <i>Falco chicquera</i>
3		+				<i>Spilornis elgini</i> , <i>S. klossi</i>
1			+			<i>Polihierax insignis</i>
1			+		+	<i>Butastur liventer</i>
5				+		<i>Spizaetus alboniger</i> , <i>S. nanus</i>
1				+	+	<i>Microhierax fringillarius</i>
3					+	<i>Spizaetus bartelsi</i> , <i>Falco moluccensis</i>
Total	35	8	24	22	18	

Andamans-Nicobars (oceanic archipelago) and Java (landbridge island), because of their endemic taxa, have been separated from the larger Indian, Indochinese and Sundan subregions.

the forest. Five species (Black Baza [*Aviceda leuphotes*], Oriental Honey-buzzard [*Pernis ptilorhynchus*], Besra [*Accipiter virgatus*], Indian Black Eagle [*Ictinaetus malayensis*], and Rufous-bellied Eagle [*Hieraaetus kienerii*]) have a wide altitudinal range, while one species (Kinabalu Serpent-eagle [*Spilornis kinabaluensis*]) is restricted to montane forest. Populations of honey-buzzards and bazas are augmented in winter when the northern subspecies migrates south. All six species easily fly between separate forest patches.

Nineteen species are associated with woodlands, edges, and open or degraded secondary forests. They are not true forest species and tolerate a moderate level of deforestation and readily accept tree plantations. Crested Serpent-eagle (*Spilornis cheela*), Shikra (*Accipiter badius*), Nicobar Sparrowhawk (*A. butleri*), Changeable Hawk-eagle (*Spizaetus cirrhatus*), White-rumped Pygmy Falcon (*Polihierax insignis*), and Red-necked Falcon (*Falco chicquera*) forage in forests from mid-level to the ground. All species of falconets (*Microhierax* spp.) take prey in flight from exposed perches, including emergent trees of closed canopies. Bat Hawks (*Macheiram-*

phus alcinus), Oriental Hobbies (*Falco severus*), and Peregrine Falcons (*F. peregrinus*) hunt above or around the forest and are more sensitive to prey abundance than to vegetation structure. Wintering migrants (Chinese Goshawk, Japanese Sparrowhawk, Eurasian Sparrowhawk, Common Buzzard, Booted Eagle [*Hieraaetus pennatus*], and Eurasian Hobby) share the least wooded habitat types.

Ten migrant and 14 resident species use open grasslands and cultivated and suburban areas. They are mostly distributed in the drier, less forested northern tropics. They appear to avoid dense forests, but only the smaller species (Black-winged Kite [*Elanus caeruleus*], two species of buzzards [*Butastur* spp.], and three species of falcons), migrants (Grey-faced Buzzard [*Butastur indicus*], Long-legged Buzzard, two species of harriers and three species of falcons), and scavengers (Black Kites [*Milvus migrans*], and six species of vultures) may actually benefit from extensive deforestation, cultivation, and overgrazing. Eagles (Short-toed Snake-eagle [*Circaetus gallicus*] and three species of *Aquila*) usually remain associated with more natural habitats.

Eleven wetland species use marshes and rice-fields, freshwater lakes, coastal lagoons, rivers and forest streams, or sea coasts. Residents are Brahminy Kite (*Haliastur indus*), White-bellied Sea-eagle (*Haliaeetus leucogaster*), Pallas's Sea-eagle (*H. leucorhynchus*), Grey-headed Fish-eagle (*Ichthyophaga ichthyaeetus*), Lesser Fish-eagle (*I. humilis*), and Lesser Spotted Eagle (*Aquila pomarina*). Migrants include Western Marsh-harrier (*Circus aeruginosus*), Eastern Marsh-harrier (*C. spilonotus*), Pied Harrier (*C. melanoleucos*), and Greater Spotted Eagle. The Osprey (*Pandion haliaetus*) has a small coastal breeding population in Java but is overall a widespread wintering species. The response of wetland raptors to habitat changes differs among species. Large piscivorous birds such as sea and fishing eagles are often adversely affected because of decreasing fish stocks and suitable trees for hunting perches along banks. More terrestrial eagles (e.g., *Aquila*) may be affected by a lack of undisturbed shallow marshes and humid grasslands, whereas more versatile species (e.g., species of *Haliastur* and *Circus*) may be benefitted because they are much more adaptable to heavy human disturbance of wetlands.

Northern migrants, except locally the Booted Eagle (*Hieraaetus pennatus*), are virtually absent from forests. They make up 32–42% of all raptor species in the other three habitat categories.

Conservation Status. The number of Threatened or Near Threatened species is alarming. Among the 49 breeding taxa, 22 have a high conservation index (5–9) and/or are in one of the categories of threat in the IUCN World Red List (Table 4, Collar et al. 1994). There is no extinct species nor is any raptor population currently dependent on a captive-breeding program. However, two subspecies of the Lesser Spotted Eagle (*Aquila pomarina hastata*) from India, and Wallace's Hawk-eagle (*Spizaetus nanus stresemanni*) from Nias Island, W. Sumatra, seem to be Critically Endangered (Thiollay 1996).

All eight forest interior species, nearly half of the more tolerant forest or wetland species, and 25% of woodland and open habitat species are considered Rare, Threatened or of Special Concern because of their high conservation index (Table 5). Only two wintering migrants are globally Vulnerable (Greater Spotted Eagle) or Near Threatened (Eurasian Black Vulture, *Aegypius monachus*). Several other migrants have small and local populations in South Asia, but they are widespread elsewhere.

Population Trends. There are very few accurate data on raptor population dynamics in South Asia or trends in recent decades, yet many species considered common or widespread 50 yr ago in regional accounts are now obviously rarer and more local. This is especially true for eagles, both from rainforests (hawk-eagles) and wetlands (fishing eagles), but also for many usually abundant species in genera such as *Milvus*, *Haliastur*, *Elanus*, *Accipiter*, *Butastur*, and *Falco*, which are now rare, if not almost extirpated from large, intensively cultivated areas in Thailand, Vietnam, Malaysia, and Java. The decline is especially striking for vultures (*Gyps* spp. and *Sarcogyps calvus*) which have apparently disappeared, at least as breeders, from vast regions in Peninsular Malaysia, Thailand, and Indochina where they were once considered common. Even in India, their main stronghold, my roadside counts over a 20-yr period show significant declines in some areas. Finally, at least the forest interior species which cannot adapt to degraded woodlands or even to fragmented secondary forest, may be decreasing in parallel with deforestation.

Specific Regional and Distribution Patterns. An increased density and a wider habitat niche of some species may result from competitive release when fewer competitors coexist, especially on islands (Wright 1980, Blondel 1990). Field measurements showed such striking examples of habitat shifts and density compensations. For example, Crested Serpent-eagles are widespread everywhere in secondary forests and woodlands in the absence of any congeners. However, on the Andaman archipelago, it is associated only with mangroves, forest edges or gaps, and deforested areas, whereas the endemic Andaman Serpent-eagle occupies all types of forest interior (Fig. 2). In another example, Changeable Hawk-eagle is restricted to open woodlands and degraded forests in India at upper elevations, in Malaysia, Borneo, and Sumatra because another *Spizaetus* always replaces it in dense forests. In Vietnam, lowland India, and the Andamans, where there is no forest *Spizaetus*, Changeable Hawk-eagles, are found throughout primary forests and more open secondary stands (Fig. 3). Altitudinal segregation occurs between Wallace's Hawk-eagle (in the lowlands) and Blyth's Hawk-eagle (at upper elevations) throughout their sympatric distribution. The Besra is a common forest raptor at any elevation from southwest India to Vietnam and Java, in sympatry with the larger Crested Goshawk. Conversely, in northern India, Nepal,

Table 4. Conservation status of breeding raptors in tropical Asia, west of the Wallace Line. The conservation index (see Methods) is given for mostly South Asian species, and not for taxa with extra world range. The IUCN status (criteria in Mace and Stuart 1994) involves only Threatened (=Endangered or Vulnerable) or Near Threatened (low risk) species.

SPECIES	CONSERVATION STATUS
Species whose world range is mostly within South Asia	
Jerdon's Baza (<i>Aviceda jerdoni</i>)	7, low risk
Black Baza (<i>Aviceda leuphotes</i>)	5
Oriental Honey-buzzard (<i>Pernis ptilorhynchus</i>)	3
Brahminy Kite (<i>Haliastur indus</i>)	2
White-bellied Sea-eagle (<i>Haliaeetus leucogaster</i>)	3
Lesser Fish-eagle (<i>Ichthyophaga humilis</i>)	6, low risk
Grey-headed Fish-eagle (<i>Ichthyophaga ichthyaetus</i>)	6, low risk
Indian White-backed Vulture (<i>Gyps bengalensis</i>)	4, low risk
Long-billed Vulture (<i>Gyps indicus</i>)	4, low risk
Red-headed Vulture (<i>Sarcogyps calvus</i>)	7, low risk
Crested Serpent-eagle (<i>Spilornis cheela</i>)	2
Nicobar Serpent-eagle (<i>Spilornis klossi</i>)	6, low risk
Kinabalu Serpent-eagle (<i>Spilornis kinabaluensis</i>)	7, data deficient
Andaman Serpent-eagle (<i>Spilornis elgini</i>)	6, low risk
Crested Goshawk (<i>Accipiter trivirgatus</i>)	5
Nicobar Sparrowhawk (<i>Accipiter butleri</i>)	7, low risk
Besra (<i>Accipiter virgatus</i>)	4
White-eyed Buzzard (<i>Butastur teesa</i>)	4
Rufous-winged Buzzard (<i>Butastur liventer</i>)	6, low risk
Indian Black Eagle (<i>Ictinaetus malayensis</i>)	4
Rufous-bellied Eagle (<i>Hieraaetus kienerii</i>)	6, low risk
Changeable Hawk-eagle (<i>Spizaetus cirrhatus</i>)	2
Mountain Hawk-eagle (<i>Spizaetus nipalensis</i>)	7, low risk
Blyth's Hawk-eagle (<i>Spizaetus alboniger</i>)	7
Javan Hawk-eagle (<i>Spizaetus bartelsi</i>)	9, Endangered
Wallace's Hawk-eagle (<i>Spizaetus nanus</i>)	9, Endangered
White-rumped Pygmy Falcon (<i>Polihierax insignis</i>)	5, low risk
Collared Falconet (<i>Microhierax caerulescens</i>)	4
Black-tighted Falconet (<i>Microhierax fringillarius</i>)	4
White-fronted Falconet (<i>Microhierax latifrons</i>)	5, data deficient
Pied Falconet (<i>Microhierax melanoleucus</i>)	5, low risk
Oriental Hobby (<i>Falco severus</i>)	4
Laggar Falcon (<i>Falco jugger</i>)	3
Species with small and marginal breeding population in South Asia, ranging mostly outside the region	
Osprey (<i>Pandion haliaetus</i>)	
Pallas's Sea Eagle (<i>Haliaeetus leucoryphus</i>)	Vulnerable
Eurasian Griffon (<i>Gyps fulvus</i>)	
Short-toed Snake-eagle (<i>Circaetus gallicus</i>)	
Lesser-spotted Eagle (<i>Aquila pomarina</i>)	Endangered
Spotted Kestrel (<i>Falco moluccensis</i>)	
Species with a substantial population in South Asia, but with a larger population elsewhere (Asia to Africa)	
Bat Hawk (<i>Macheiramphus alcinus</i>)	
Black-winged Kite (<i>Elanus caeruleus</i>)	
Black Kite (<i>Milvus migrans</i>)	
Egyptian Vulture (<i>Neophron percnopterus</i>)	
Shikra (<i>Accipiter badius</i>)	
Tawny Eagle (<i>Aquila rapax</i>)	

Table 4. Continued.

SPECIES	CONSERVATION STATUS
Bonelli's Eagle (<i>Hieraaetus fasciatus</i>)	low risk
Common Kestrel (<i>Falco tinnunculus</i>)	
Red-necked Falcon (<i>Falco chicquera</i>)	
Peregrine Falcon (<i>Falco peregrinus</i>)	

Borneo, Sumatra, and maybe Malaysia, it is confined to upper elevations (1000–2000 m) separated from the Crested Goshawk which occurs alone in the lowlands.

When all species were pooled, the density index of raptors in mature forests (but not in deforested habitats) was similar in the study areas of southwest India, southern Vietnam and western Sumatra, but it increased significantly in Sri Lanka and the Andaman Islands (+45%, $P < 0.001$, Table 6). Most taxa exhibited a significant density increase in undisturbed forests both between small and large islands and between islands and continental areas. The two Serpent-eagles in the Andamans reached extremely high densities in their preferred habitat: 2.78 birds/km² sample plot for Andaman Serpent-eagles in primary forests and 2.25 birds/km² for Crested Serpent-eagles in mangroves vs. 0.71–0.98 birds/km² for the latter in continental woodlands. The abundance of Black Bazas (*Aviceda leuphotes*) was three times higher in the Andamans than in Vietnam. However, the density of the one species of goshawk and hawk-eagle in Andamans was equaled and even surpassed by the cumulative abundance of all goshawks or hawk-eagles and eagle species (*Hieraaetus* spp.) in the forests of the four other study areas. High population densities enable birds on relatively small islands to minimize their extinction risk. A higher tolerance to habitat change or disturbance may also allow them to bet-

ter withstand human-made habitat degradation and fragmentation which tend to be especially severe on islands.

MAIN THREATS AND CONSERVATION ISSUES

Habitat Loss. Most natural habitats in tropical Asia are decreasing primarily because of deforestation. Most areas with fertile, deep soils have long histories of cultivation. The few remaining forests are on infertile soils, peat swamps, and steep slopes that support poorer forest types and less complex animal communities (Collins et al. 1991). Lowland rainforests, the richest of them all, are most at risk and are the target of most new settlements. Moist forests were disappearing during the early 1980s at an estimated rate of 17 000 km²/yr within our study area alone (FAO 1988, Collins et al. 1991) and there is no evidence that this trend has decreased since then. Clearcutting for either shifting or permanent industrial cultivation is the main cause of deforestation. In monsoon forests, heavy collection of fuel wood is an additional pressure. Montane forests are more secure because of their poor accessibility and suitability for agriculture but they have also lower raptor species richness. In northern Borneo and western Sumatra, I recorded 10–11 species in all primary forests surveyed below 1200 m while at 1200–2200 m, there were only 4–6 species.

The destruction of swamp and riverine forests

Table 5. Status, habitat selection and conservation of raptors in South Asia. Number of species in each category among the 69 regular species.

	RESIDENT	WINTERING	RARE ^a	THREATENED ^b
Mature forest interior species	8		4	8
Gap tolerant forest species	6		2	3
Woodland or forest edge species	14	6	5	5
Dry open habitat species	14	10	8	6
Wetland species	7	4	5	5

^a Rare = low density and/or patchy distribution in suitable habitats.
^b Threatened = Endangered to low risk, data deficient and/or conservation value 5–9.

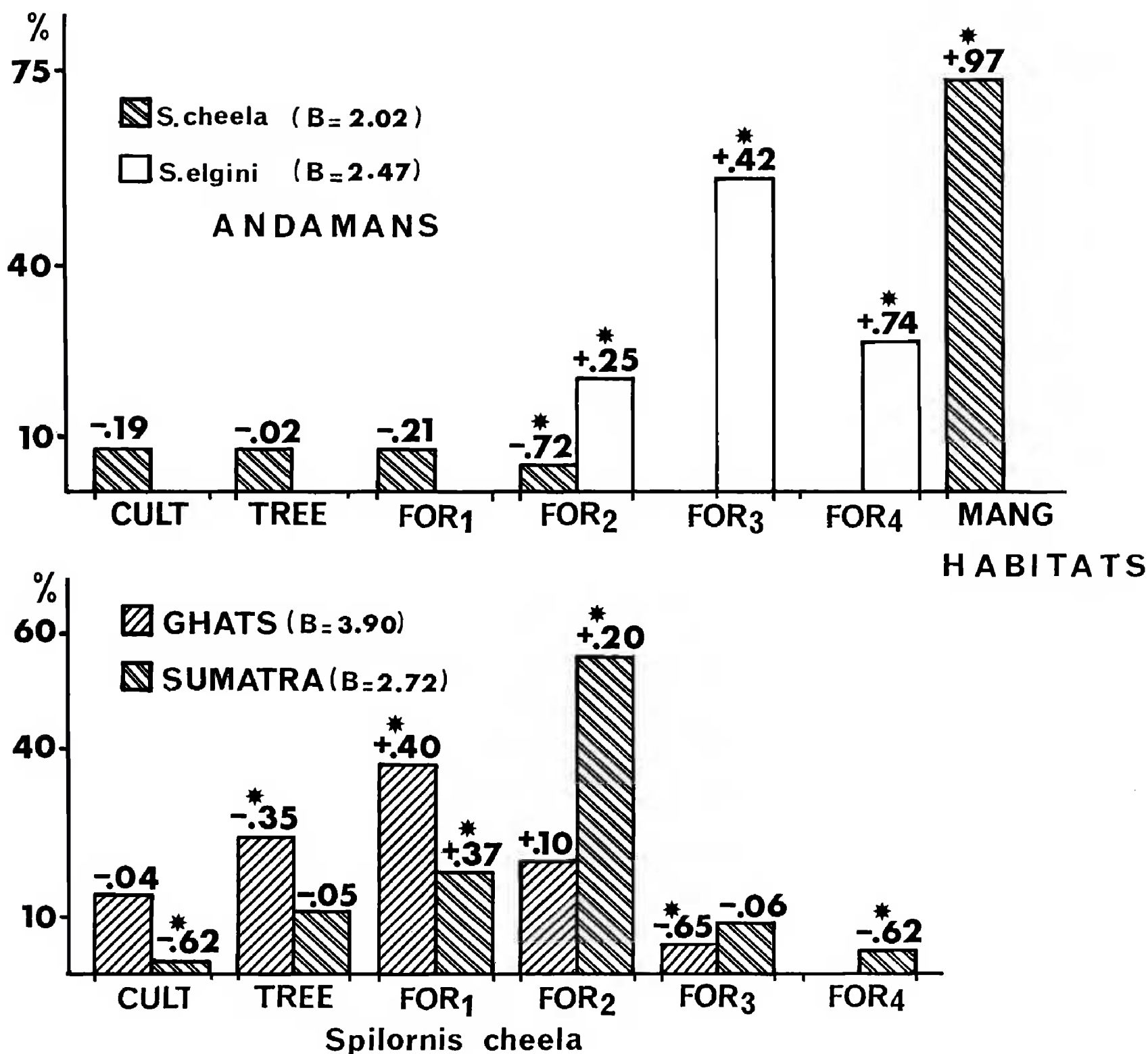


Figure 2. Comparative distribution of the widespread Crested Serpent-eagle (*Spilornis cheela*) in India, Sumatra, and Andamans and the endemic Andaman Serpent-eagle (*S. elgini*) in the Andamans. Percentages of random records in each habitat category (see text for definition). B = habitat niche breadth. Values on bars are the selection indices from relative habitat availability. * = statistically significant positive or negative selection (Neu et al. 1974).

affects eagles and the drainage of wetlands is detrimental to harriers and other wintering migrants. Ricefields that replace marshes are much poorer in vertebrate prey, and mangroves are heavily used for timber and shrimp farming. Large mangrove forests in estuaries, such as the Sundarbans (Sarker 1986), harbor dense populations of several raptors that have already been lost from similar areas in southern Vietnam (Morris 1986).

Habitat Degradation. Habitat degradation is an insidious, widespread phenomenon that diminish-

es the quality of natural habitats. Raptor communities become less complex in these areas and their overall density may also decline. From open woodlands to undisturbed rainforests in all five study areas, the overall mean species richness per sample plot increased by 162% and the mean abundance index by 176% (Table 4).

The main causes of forest degradation are logging and shifting cultivation. Both lead to secondary stands whose general characteristics include lower and more open canopies, a reduced number

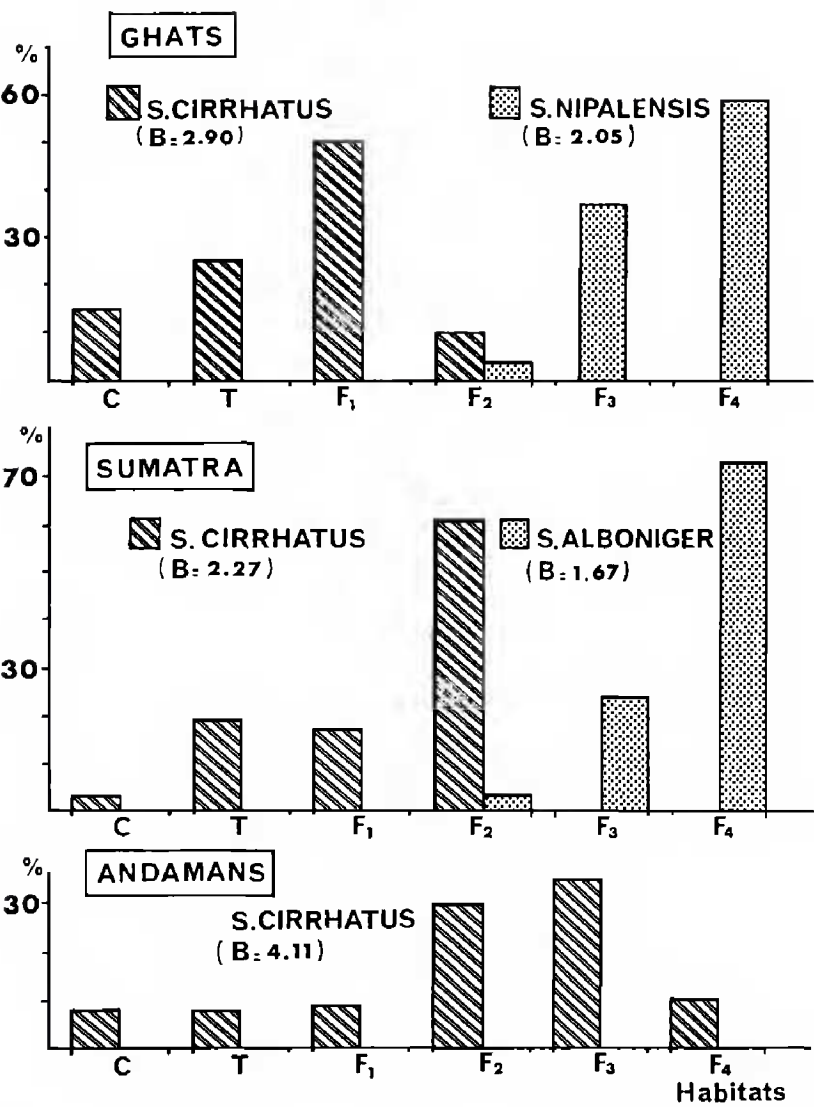


Figure 3. Comparative distribution of Changeable Hawk-eagle (*Spizaetus cirrhatus*) with a forest congener in India and Sumatra and without competitor in the Andaman Islands. Symbols as in Fig. 2.

and diversity of large trees, a denser undergrowth, and a higher frequency of gaps and dense vine tangles than primary forest. Effects of logging are severe (Burgess 1971). During the first years after logging, the density, diversity, and accessibility of many prey species decrease markedly (Wilson and Johns 1982, Johns 1985, 1986, 1987, Bennett and Dahaban 1995, Hill et al. 1995), although a partial recovery occurs after 10 yr and suitable management practices may minimize losses (Johns 1989, 1992). The ultimate stages of forest degradation are dense stands of bamboo (*Bambusacae*) or patches of high coarse grass (*Imperata cylindrica*), both of which prevent forest regeneration and are unsuitable for most raptors.

Road building through forests brings disturbance, hunting, gaps, and dense edges. Sylviculture leads to decreasing biodiversity and permanently submature stands because some fast-growing species are favored over hardwoods (Panayotou and Ashton 1992). The widespread exploitation of minor forest products, especially resins and rattans (*Calamus* sp.) is an additional cause of disturbance and hunting.

Raptor species adapting to man-made habitats naturally occur in open grasslands, woodlands, forest edges, and gaps. They are generalists and have a wide distribution. Most artificial landscapes are unsuitable for dense forest specialists with industrial tree plantations being the poorest. Even the diversified traditional agroforests of Indonesia do not conserve more than half the forest raptor species and only as long as natural forest remains

Table 6. Mean number of raptor/species and adult birds on sample plots surveyed in five areas of South Asia.

		SW GHATS (INDIA)	SOUTH VIETNAM	WESTERN SUMATRA	SRI LANKA SW	ANDAMANS
TOTAL NUMBER OF 1-km ² SAMPLE PLOTS		156	56	103	18	130
Open habitats (CULT + TREE)	Species richness/ plot ($\bar{x} \pm SD$)	1.71 \pm 1.14	1.21 \pm 1.05	0.47 \pm 0.15	1.00 \pm 0.63	0.79 \pm 0.17
	Individuals/plot ($\bar{x} \pm SD$)	2.37 \pm 1.74	2.00 \pm 1.46	0.77 \pm 1.09	1.17 \pm 0.75	1.04 \pm 1.12
Degraded forests, agroforests and mangroves (FOR 1 + FOR 2)	Species richness/ plot ($\bar{x} \pm SD$)	2.11 \pm 0.77	1.77 \pm 1.36	1.29 \pm 0.77	2.50 \pm 0.54	1.77 \pm 0.82
	Individuals/plot ($\bar{x} \pm SD$)	3.06 \pm 1.24	2.77 \pm 2.04	1.83 \pm 0.15	4.17 \pm 1.16	2.77 \pm 1.45
Primary or little disturbed forests (FOR 3 + FOR 4)	Species richness/ plot ($\bar{x} \pm SD$)	2.55 \pm 0.97	2.45 \pm 1.08	2.64 \pm 0.87	3.33 \pm 1.63	2.60 \pm 0.65
	Individuals/plot ($\bar{x} \pm SD$)	3.65 \pm 1.47	3.67 \pm 1.68	3.43 \pm 1.16	4.33 \pm 1.36	5.20 \pm 1.51

nearby (Thiollay 1995). Many dams, built in agricultural areas, are favored by Black and Brahminy Kites, Grey-headed Fish-eagle, and wintering harriers which also benefit from irrigated and more wooded surroundings.

Forest Fragmentation and Insularization. Because of their necessarily large foraging range, low density, and sensitivity to disturbance, forest raptors may be severely affected by forest fragmentation, especially forest interior species that are reluctant to cross large open areas. In lowland forest study areas of India, Sri Lanka, Vietnam, and Sumatra, there were 0.16–0.34 bazas, hawk-eagles, eagles (*Hieraaetus* spp.) or Besras per km². Assuming that there was at least an extra bird for each territorial pair, these figures represented an average density of about one pair of each species/1000–1500 ha of primary forest.

Two examples illustrate the magnitude of the fragmentation process. In the 1600-km long western Ghats of Peninsular India, only 20 000 km² of humid evergreen forest remain, but the largest undisturbed continuous fragment is the 90 km² Silent Valley National Park (Daniels 1996). In Cochinchina (23 500 km²), a single 280 km² patch of semi-evergreen forest remains (approximately 1% of the province) within the 350 km² Nam Cat Tien National Park. The Indian Black Eagle, formerly recorded, has not been found there during recent intensive surveys.

In the Andaman archipelago, the most extinction-prone raptors on small islands were the rarest and most specialized species, but unexpectedly they were also the smallest ones. Serpent-eagles and hawk-eagles were found on all islands smaller than 1 km². Some pairs range over two or three small islands showing a high tolerance to naturally fragmented forest (Thiollay 1997).

Persecution and Pollution. Raptor shooting is common, as well as trapping and nest robbing for pets, trophies, and sales to restaurants. Trade is especially prominent in Indonesia, Thailand, and Indochina. The lack of hunting in large parts of India results in an obviously higher frequency of raptors in densely inhabited areas than anywhere else. Hunting and trapping pressure, however, may have even more severe effects through reduction of prey species, notably for eagles. In large parts of Indochina, wildlife has been reduced to extremely low levels. Overfishing in streams, lakes, and marshes may also be a limiting factor for piscivorous eagles.

There is no monitoring of pesticide levels in

Asian raptors nor definite evidence of their effects. However, pesticides are heavily used in most countries (except Laos), especially Indonesia and Thailand. Ricefields are routinely sprayed even in remote areas. This trend is probably increasing because of the intensification of agriculture and the use of more productive but pest-sensitive new varieties. The dramatic disappearance of raptors from several cultivated regions (e.g., Java [van Balen et al. 1993], Thailand [Lekagul and Round 1991], and Vietnam [Thiollay pers. obs.]) suggests that pesticides have had a negative effect on raptors over the last 20 yr. No comparable declines have been recorded in forested or little-cultivated areas.

The disappearance of the once common vultures and kites in populated areas, especially Thailand, Indochina, and Malaysia, can be explained by a lower food availability due to increased sanitation. This may have also begun to occur in India.

CONCLUSIONS AND RECOMMENDATIONS

In summary, tropical Asian raptors may be divided into three broad groups from a conservation point of view. First, true forest species mostly sensitive to habitat loss, degradation, and fragmentation, need protected areas of undisturbed forests. The second group includes forest edge or gap and woodland species that are more tolerant to forest disturbance and opening. Their conservation requires habitat management, measures to minimize the effects of habitat changes, and provision of their minimum needs in terms of tree cover and prey availability. Most wetland species are also dependent on habitat management actions. The last group includes the grassland species which are more adaptable to human activity and are now largely found in cultivated and deforested areas. Their highest management priority is the direct protection from persecution and pollution. Most migrants also fall in this category.

Basic knowledge necessary to design appropriate conservation strategies is often lacking. Specific ecological requirements are little known, population levels and trends are not quantitatively documented, and threats and causes of declines are poorly understood. Also, demographic parameters, minimum viable population sizes, and dispersal abilities have never been investigated in most Asian raptor species. An intensive survey and conservation action plan are currently in progress only for the Javan Hawk-eagle (estimated population 100

pairs, van Balen 1995). Assessing the distribution, size, and viability of remaining populations of threatened forest and wetland eagles such as hawk-eagles and fishing eagles is an urgent priority. Only immediate measures could save the Critically Endangered subspecies of the Wallace's Hawk-eagle (*Spizaetus nanus stresemanni*) from Nias Island or the Lesser Spotted Eagle (*Aquila pomarina hastata*) from Indo-gangetic plains.

The extension and enforcement of the current network of protected areas is a high priority. Protected areas cover only 4.5% of Southeast Asia (IUCN 1990) and many of them are heavily disturbed and increasingly encroached by people. The highest conservation priority is the lowland rainforest which is fast disappearing everywhere. Forest management policies must promote biodiversity conservation in production forests, reduce logging damages, maintain a network of unlogged patches, and avoid large plantations of exotic trees. Tree cash crops could be made more hospitable to raptors by increasing their structural and floristic diversity, and traditional agroforests must be encouraged (Thiollay 1995). Finally, cultivated areas become the most widespread habitat and the main wintering ground for migrants. Therefore, their sound management is a priority for the conservation of raptors in Asia, with an emphasis on the maintenance of trees and fallow patches, and a drastic reduction of hunting pressure and pesticide use.

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Appendix 1. Status and distribution of raptors in South Asia. B = breeding but may include additional, wintering nonresident populations; W = only wintering migrants, usually from Eastern Palearctic zone. Number of subspecies in parentheses after species names.

[illegible]

Appendix 1. Continued.

	N INDIA	PEN. INDIA	SRI LANKA	NE INDIA	ANDA- MANS	BUR- MA	THAI- LAND	VIET- NAM	MALAY PEN.	SARA- WAK	S BOR- NEO	SUMA- TRA	JAVA
Montagu's Harrier													
<i>Circus pygargus</i> (1)	W	W	W	W									
Western Marsh Harrier													
<i>Circus aeruginosus</i> (1)	W	W	W	W									
Eastern Marsh Harrier													
<i>Circus spilonotus</i> (1)						W	W	W	W	W		W	
Crested Goshawk													
<i>Accipiter trivirgatus</i> (7)	B	B	B	B		B	B	B	B	B	B	B	B
Shikra													
<i>Accipiter badius</i> (4)	B	B	B	B		B	B	B					
Nicobar Sparrowhawk													
<i>Accipiter butleri</i> (2)					B								
Chinese Goshawk													
<i>Accipiter soloensis</i> (1)					W	W	W	W	W	W	W	W	W
Japanese Sparrowhawk													
<i>Accipiter gularis</i> (2)					W	W	W	W	W	W	W	W	W
Besra													
<i>Accipiter virgatus</i> (7)	B	B	B	B	B	B	B	B	B	B	B	B	B
Eurasian Sparrowhawk													
<i>Accipiter nisus</i> (1)	W	W	W	W		W	W	W					
White-eyed Buzzard													
<i>Butastur teesa</i> (1)	B	B		B		B							
Rufous-winged Buzzard													
<i>Butastur liventer</i> (1)						B	B	B					
Grey-faced Buzzard													
<i>Butastur indicus</i> (1)							W	W	W	W	W	W	W
Common Buzzard													
<i>Buteo buteo</i> (2)	W	W	W	W		W	W	W					W
Long-legged Buzzard													
<i>Buteo rufinus</i> (1)	W												
Indian Black Eagle													
<i>Ictinaetus malayensis</i> (2)	B	B	B	B		B	B	B	B	B	B	B	B
Lesser Spotted Eagle													
<i>Aquila pomarina</i> (1)	B			B									
Greater Spotted Eagle													
<i>Aquila clanga</i> (1)	W			W		W	W	W					
Tawny Eagle													
<i>Aquila rapax</i> (1)	B	B		B		B	W						
Steppe Eagle													
<i>Aquila nipalensis</i> (1)	W	W		W		W							
Eurasian Imperial Eagle													
<i>Aquila heliaca</i> (1)	W			W				W					
Bonelli's Eagle													
<i>Hieraaetus fasciatus</i> (1)	B	B		B		B	B	B					
Booted Eagle													
<i>Hieraaetus pennatus</i> (1)	W	W		W		W			W				
Rufous-bellied Eagle													
<i>Hieraaetus kienerii</i> (2)		B	B	B		B	B	B	B	B	B	B	B
Changeable Hawk-eagle													
<i>Spizaetus cirrhatus</i> (5)	B	B	B	B	B	B	B	B	B	B	B	B	B
Mountain Hawk-eagle													
<i>Spizaetus nipalensis</i> (2)	B	B	B	B		B	W	W					

Appendix 1. Continued.

	N INDIA	PEN. INDIA	SRI LANKA	NE INDIA	ANDA- MANS	BUR- MA	THAI- LAND	VIET- NAM	MALAY PEN.	SARA- WAK	S BOR- NEO	SUMA- TRA	JAVA
Blyth's Hawk-eagle													
<i>Spizaetus alboniger</i> (1)									B	B	B	B	
Javan Hawk-eagle													
<i>Spizaetus bartelsi</i> (1)													B
Wallace's Hawk-eagle													
<i>Spizaetus nanus</i>									B	B	B	B	
White-rumped Pygmy Falcon													
<i>Polihierax insignis</i> (3)						B	B	B					
Collared Falconet													
<i>Microhierax caerulescens</i> (2)	B			B		B	B	B					
Black-thighed Falconet													
<i>Microhierax fringillarius</i> (1)									B	B	B	B	B
White-fronted Falconet													
<i>Microhierax latifrons</i> (1)										B			
Pied Falconet													
<i>Microhierax melanoleucus</i> (1)				B		B		B					
Lesser Kestrel													
<i>Falco naumanni</i> (1)	W	W		W									
Common Kestrel													
<i>Falco tinnunculus</i> (2)	W	B	B	W		W	W	W					
Spotted Kestrel													
<i>Falco moluccensis</i> (1)													B
Red-necked Falcon													
<i>Falco chicquera</i> (1)	B	B											
Merlin													
<i>Falco columbarius</i> (2)	W							W					
Eurasian Hobby													
<i>Falco subbuteo</i> (2)	W	W		W		W	W	W					
Oriental Hobby													
<i>Falco severus</i> (1)	B	W	W	B		B	B	B					B
Laggar Falcon													
<i>Falco jugger</i> (1)	B	B		B		B							
Saker Falcon													
<i>Falco cherrug</i> (1)	W			W									
Peregrine Falcon													
<i>Falco peregrinus</i> (5)	B	B	B	B	W	B	W	W	B	B	B	B	B
Total breeding	31	28	17	31	8	31	23	23	19	20	18	18	18
Total wintering	16	11	9	14	5	13	15	15	10	6	5	6	4

Pen = Peninsular, Andamans = +Nicobars, Thailand = +Cambodia, Vietnam = +Laos, Sarawak = +Sabah.